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Glycaemic control and its associated factors among adult Omanis with type 1 diabetes mellitus: a cross-sectional survey

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ABSTRACT

Objectives: This study aimed to investigate the relationship between glycemic control and diabetes self-management (DSM) and other associated factors among adult Omanis with Type-1 Diabetes Mellitus (T1DM).

Methods: A cross-sectional, descriptive design was used to collect data among 210 adult Omanis with T1DM who were conveniently recruited. All tools were self-reported, whereas the HbA1c was collected from the patient's electronic medical records.

Results: The HbA1c mean value was 8.6 ($SD = 2.5$), 30.5% had optimal glycemic control (<7.0). A significant negative relationship between HbA1c and DSM ($r = -0.191$, $p = 0.006$) and diabetes knowledge ($r = -0.153$, $p = 0.026$) was found. Furthermore, the mean HbA1c was significantly lower for persons with a single marital status, have higher education level, have children, are unemployed, were not admitted to the hospital in the last year, and have a health care professional as a family member. Additionally, marital status, level of education, DSM, and social support were significant predictors of glycemic control.

Conclusions: The results suggested that better glycemic control could be achieved by optimizing DSM, social support, and diabetes knowledge. Sociodemographic factors should be considered when treating individuals with T1DM to reach good glycemic control.

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Diabetic self-management; glycemic control; T1DM; Oman; predictors

1. Introduction

Glycemic control continues to be one of the main objectives of diabetes management [1]. According to the American Diabetes Association (ADA), glycemic control is defined as maintaining a blood glucose level for a person with diabetes within the recommended targets [2]. Different key clinical trials have demonstrated a significant reduction in the risk of cardiovascular disease and other diabetic complications with tight glycemic control [3,4]. According to ADA, glycemic control is best assessed by glycosylated hemoglobin (HbA1c) level. The ADA recommended performing the HbA1c at least two times annually for persons who are meeting the glycemic control targets and every 3 months for persons who have changed their treatment regimen for not meeting the glycemic targets [2]. The HbA1c was discovered in the 1960s [5] and was proposed as a diagnostic marker by the European Association for the Study of Diabetes (EASD) and the ADA in 2009 [6] and by the World Health Organization (WHO) in 2011 with a cutoff point of HbA1c < 6.5% diagnose diabetes [7]. The ADA [8] recommended that the target value of the HbA1c be below 7.0% for the appropriate glycemic control. Although the ADA suggested general targets for glycemic control, ADA emphasized that these goals must be individualized in the context of shared decisions that take into account patient preferences and individual characteristics [2]. Therefore, studying patient factors, risk factors, and other cultural factors is considered the essential step in targeting glycemic control in any population.

Individuals with Type 1 diabetes mellitus (T1DM) require intensive insulin therapy in addition to the other seven essential behaviors of healthy eating, medication adherence, glucose monitoring, exercise, problem-solving skills, and risk reduction behavior. These behaviors are positively associated with good glycemic control [9,10]. Optimal glycemic control leads to a reduction or prevention of DM-related complications [9,11]. A reduction in HbA1c of 1.8% from the mean value is associated with a reduction in the development of new retinopathy, neuropathy, and micro-albuminuria of 76%, 60%, and 39%, respectively [11].

Different factors are associated with optimal DM glycemic control, such as socio-demographic characteristics, self-efficacy (SE), social support (SS), and diabetes knowledge (DK) [12–17]. A cross-sectional analysis of the electronic medical records of 2,276 T1DM revealed that the mean value of HbA1c was lower among the younger group

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compared to the older group [15]. Furthermore, they had no or fewer complications [15]. This result is consistent with a study done to assess factors associated with diabetic nephropathy in children, adolescents, and adults with T1DM [16]. The study showed that HbA1c and age are two of the important factors associated with nephropathy. Furthermore, early detection of micro-albuminuria and proper treatment with Angiotensin Converting Enzyme Inhibitors (ACEI) or Angiotensin II Receptor Blockers (ARBs) and improving glycemic control could delay the progression of diabetes nephropathy [16].

The study showed that 50% of the participants had a high HbA1c (more than 7.0%) with low self-management behavior. Participants with high diet SE and greater diet self-management behavior were associated with low HbA1c [13]. This result is similar to the findings of another study, which showed that low self-management and high levels of diabetes distress were associated with high HbA1c. Moreover, understanding diabetes care has been reported to be associated with better outcomes of HbA1c, but no significant association between HbA1c and SE and risk awareness [17].

Alrahbi [14] also found no significant relationship between DSM and glycemic control, and the reasons for this result were stated to be participants who performed DSM for a short period before testing the level of HbA1c to be reflected in the test, and the lack of consistency in performing DSM. The psychosocial attributes associated with difficulty in DSM include DM emotional distress and this leads to poor glycemic control and worse DM condition over time [17]. Most studies that have assessed HbA1c and DSM in the Omani population have focused on T2DM [14,18,19]. On the other side, T1DM within the Omani population has gained less attention. Indeed, through a critical examination of the existing literature, we allocated only one study [20] that has addressed the glycemic control among Omanis with TIDM. Although the study by Hafidh and Abdella [20] suggested that the prevalence of optimal glycemic control (HbA1c > 7%) among Omanis with T1DM is 8%, this figure may not be accurate as the total sample from the Omani population in that study was only 18 T1DM people. Furthermore, statistics of the Omani population indicate that about 38.4% of the total population is <15 years old [21] with a median age of 26.2 years [22]. With a young population, T1DM became a public concern with an estimated DM prevalence rate of 11.8% in Oman [23]. With the scarcity of information about glycemic control among Omanis with T1DM, it is important to investigate this phenomenon and its associated factors to suggest effective programs to enhance glycemic control among this population. Therefore, this study aimed to investigate the relationship between glycemic control and DSM and other associated factors among adult Omanis with T1DM. Specific research questions for the current study are as follows:

a. What is the level of glycemic control among Omanis with TIDM?
b. What factors are associated with glycemic control among Omanis with T1DM?
c. What are the predictors of glycemic control among Omanis with T1DM?

2. Methods

2.1. Research design

A cross-sectional, descriptive design was implemented to collect data on glycemic control among Omanis with T1DM and its associated factors. The glycosylated hemoglobin (HbA1c) was assessed as the clinical outcome variable. The level of HbA1c was assessed along with the level of diabetes self-management, self-efficacy, social support, Diabetic knowledge, and sociodemographic characteristics. All tools were originally in the English language and then translated into the Arabic language using the standard procedure of translation and back translation [24]. The final copies of the Arabic version of the instruments were validated for readability, clarity, and content by two researchers with a Doctoral degree and one diabetes nurse with a Master's degree. The final versions were pilot-tested before the main data collection.

2.2. Study variables

The HbA1c was collected from the patient medical electronic record. In this study, optimal glycemic control was defined according to the ADA recommendation of maintaining HbA1c less than 7% for persons with diabetes [25]. The diabetes self-management questionnaire was utilized to assess the level of DSM, which consists of 27 items 4-point Likert scale. The original English version of the tool was reported to be reliable with a Cronbach alpha of 0.84 [26] and 0.83 of the Arabic version in the previous study [27]. The total DSM score was categorized as good (8–10), poor (4–7), and very poor (<4) [28]. Diabetic self-efficacy was assessed using the empowerment scale short form [29]. The scale consists of 8 items of a 5-point Likert scale with a reliability Cronbach's alpha of 0.84 for the original English version [30] and a similar reliability in the Arabic version as published in the first publication of this study [27]. The social support was assessed by the medical outcome study SS survey. The survey consists of 19 items on a 5-point Likert rating scale with four domains (emotional or informational, tangible, affectionate, and positive social interaction). The reliability of Cronbach's alpha is > 0.90 for the original version [31] as well as for the Arabic version in a previous study [27]. The Diabetes knowledge was assessed by utilizing the DK test, which consists of 23 multiple choice items appropriate for patients on insulin treatment [29]. The reliability of Cronbach's alpha is 0.77 for the original English version [32] and 0.63 for the Arabic version in the previous study [27]. The total knowledge score was categorized as low knowledge (1–11), moderate (12–18), and high (19–23) according to the Zowgar study [33].

2.3. Study setting and sampling procedure

A total of 210 adult Omanis with T1DM (aged ≥18 years) were recruited in this study. Participants were selected by convenient sampling and asked to participate and give their consent to voluntarily participate in the study during their regular visits to the diabetic clinic. The medical records of the patients were reviewed to exclude patients with mental or cognitive problems. Ethical approval was secured from the study hospitals and the review board of the principal investigator-affiliated university (Protocol No., Anonymized). Informed consent was obtained from all the study participants after a full explanation of the study's purpose and procedure.

2.4. Data analysis

All analyses were run using SPSS (version 23) statistical software. Frequency mean and standard deviations were used to describe the study sample and the outcome variables. Further, to test the significant differences in mean HbA1c across different variables, the independent *t*-test and one-way Analysis of variance (ANOVA) were used with equality of variance being verified. An Independent t-test was used to camper the means of two independent groups (e.g. male vs. female). On the other hand, ANOVA was used to compare the means of three independent groups (e.g. 3 levels of education). The statistical significance level for the current study was set at $p > 0.05$. No statistical procedure was used to replace missing data as no missing data were observed for the variables included in the final analyses.

3. Results

3.1. Sociodemographic characteristics

Comparison of means HbA1c in relation to socio-demographic characteristics is shown in Table 1. Of the 210 participants, 70.5% were female and had a mean age of 26.82 years (*SD* = 8.25). About 46.2% of the participants were married. The majority of the participants (51.4%) had a secondary school

Table 1. Comparison of means HbA1c in relation to socio-demographic characteristics.

Variable	n (%)	Mean (SD)	t	p
Gender				
Male	62 (29.5)	9.1 (2.9)	1.7	0.09
Female	148 (70.5)	8.4 (2.3)		
Marital Status				
Single	113 (53.8)	9.3 (2.7)	5.0	< 0.001
Married	97 (46.2)	7.7 (2.0)		
Has Children				
No	130 (61.9)	9.0 (2.6)	3.7	< 0.001
Yes	80 (38.1)	7.8 (2.2)		
Level of Education				
Secondary or Less	108 (51.4)	9.1 (2.8)	3.0	0.003
Diploma or Higher	102 (48.6)	8.0 (2.0)		
Employment Status				
Unemployed	136 (64.8)	9.1 (2.6)	4.1	0.000
Employed	74 (35.2)	7.7 (2.0)		
Admission in the Last Year				
No	150 (71.4)	8.3 (2.3)	-2.3	0.03
Yes	60 (28.6)	9.2 (2.9)		
Has Other Chronic Disease				
No	162 (77.1)	8.6 (2.6)	-0.3	0.8
Yes	48 (22.9)	8.7 (2.4)		
Family Member with DM				
No	53 (25.2)	8.5 (2.1)	-0.3	0.8
Yes	157 (74.8)	8.6 (2.6)		
HCP Family Member				
No	126 (60)	8.9 (2.5)	2.2	0.03
Yes	84 (40)	8.1 (2.5)		
Variable	n (%)	Mean (*SD*)	F	*p*
Age Group in Years				
18 – 28	137 (65.2)	8.9 (2.7)	5.5	0.005
29 – 39	52 (24.8)	7.6 (1.9)		
≥ 40	21 (10)	8.8 (2.3)		
Monthly Income (OMR)				
< 300	30 (14.3)	9.1 (2.6)	0.9	0.4
300 – 1000	122 (58.1)	8.5 (2.4)		
> 1000	58 (27.6)	8.6 (2.7)		
Period of DM Diagnosis				
0 – 3	39 (18.6)	8.6 (2.4)	0.02	1.0
3.1 – 5	26 (12.4)	8.7 (2.6)		
> 5.1	145 (69.0)	8.6 (2.6)		
HbA1c Categories**				
Optimal glycemic control	64 (30.5)	6.1 (0.55)	256	< 0.001
Medium glycemic control	70 (33.3)	8.0 (2.1)		
Poor glycemic control	76 (36.2)	11.2 (2.5)		

SD: Standard Deviation; HbA1c: Glycosylated Hemoglobin Control; DM: Diabetes Mellitus; HCP: Health Care Professional; OMR: Omani Riyal. * Statistically Significant *p* value < 0.05. ** HbA1c categories: Optimal glycemic control (<7%), Medium glycemic control (7% – 9%), Poor glycemic control (<9%).

education or less, unemployed (64.8%) with a monthly income ranging between 300 and 1,000 OMR [$ US 2,61] (58.1% of the participants). Most of the participants (69%) had been diagnosed with T1DM more than 5 years and few of them (28.6%) had been admitted to the hospital within the last 12 months. Most of the participants (74.8%) reported they had a family member with DM and did not have other chronic diseases) (77.1%). Less than half of the participants (30.5%) had good glycemic control.

3.2. HbA1c and associated factors

The HbA1c mean value was 8.6 ($SD = 2.5$). Of the total participants, only 30.5% had optimal glycemic control. The HbA1c mean value is compared across different sociodemographic characteristics. The results showed that the mean HbA1c was significantly lower for persons with a single marital status, higher education level, have children, unemployed, were not admitted to the hospital in the last year, and have a family member of a health care professional (Table 1).

The result showed that the HbA1c mean value of participants who were single ($M = 9.3$, $SD = 2.7$) was higher than those who were married ($M = 7.7$, $SD = 2.0$, $p < 0.001$). Furthermore, the result revealed that the unemployed participants ($M = 9.1$, $SD = 2.6$) had higher mean HbA1c values than those employed ($M = 7.7$, $SD = 2.0$, $p < 0.001$). The mean values were also higher among participants who did not have children ($M = 9.0$, $SD = 2.6$) compared to participants who had children ($M = 7.8$, $SD = 2.2$, $p < 0.001$). Furthermore, participants who had secondary school or less ($M = 9.1$, $SD = 2.8$) had higher mean HbA1c values than those with a diploma or higher ($M = 8.0$, $SD = 2.0$, $p = 0.003$). Furthermore, the mean values were higher among the participants admitted within the last 12 months ($M = 9.2$, $SD = 2.9$) than among those not admitted ($M = 8.3$, $SD = 2.3$, $p = 0.03$). Furthermore, participants who did not have an HCP family member ($M = 8.9$, $SD = 2.5$) had higher mean HbA1c values than those who had an HCP family member ($M = 8.1$, $SD = 2.5$, $p = 0.03$). The result showed that the mean HbA1c values were statistically different between age groups ($F = 5.5$, $p = 0.005$). Post hoc comparisons using the Tukey test showed that the mean age group of HbA1c value 29–39 years ($M = 7.6$, $SD = 1.9$) was less than those in the age group fallen between 18 and 28 years ($M = 8.9$, $SD = 2.7$, $p = 0.003$). Pearson's correlation showed a significant negative relationship between HbA1c and DSM ($r = -0.191$, $p = 0.006$) and DK ($r = -0.153$, $p = 0.026$) (Table 2).

A multiple linear regression procedure was used to identify possible predictors of HbA1c within the current study sample. Assumptions of the regression analysis were validated including the normality assumption. The results revealed no serious threat to normality was noted. The variables initially entered in the model were age, gender, marital status, level of education, employment status, income, period of DM diagnosis, other chronic diseases, admission in the last year, DSM, and SS. The 'enter selection' method was used to exclude non – non-significant variables. The final model was tested against the constant model and found to be statistically significant ($F = 5.013$, $p < 0.0001$), with $R^2 = 0.22$ and an adjusted $R^2 = 0.18$. The variables retained in the final model were marital status, level of education, DSM, and SS (Table 3).

4. Discussion

Glycemic control is the main goal of diabetes treatment and management [19] and it can be done by encouraging individuals to engage in DSM [18]. This study found that the mean value of HbA1c was 8.6 and only 30.5% achieved good glycemic control. This result is consistent with the results reported by other studies done among Omanis with type 2 diabetes mellitus (T2DM) which reported a mean value of 8.4 for HbA1c and 30% of the participants had normal glycemic control [18], and Al-Lawati et al. [34], who reported a mean HbA1c value of 8.2 and only 32% achieved good glycemic control. This finding indicates that both T1DM and T2DM Omanis have suboptimal glycemic control. Furthermore, the results from our study are consistent with results from other studies conducted around the globe, which demonstrated that enhanced DSM is associated with better glycemic control [35,36]. Several factors could explain the suboptimal glycemic control among Omanis with T1DM such as socio-demographic characteristics (e.g. age group, marital status, children in the family, level of education, and employment status), DSM, and DK.

In the current study, the mean value for participants in the age group between 29 and 39 years ($M = 7.6$, $SD = 1.9$) was lesser than those in the age group between 18 and 28 years ($M = 8.9$, $SD = 2.7$, $p < 0.01$). This result is a similar previous study among Omanis with T2DM, in which the

Table 2. Pearson correlation between HbA1c and other continuous variables.

Variable	HbA1c	DSM	DSE	SS	DK
HbA1c	-				
DSM	−0.191**	-			
DSE	−0.086	0.265**	-		
SS	−0.039	0.268**	0.319**	-	
DK	−0.153*	0.151*	0.187**	0.179**	-

r: Pearson correlation; HbA1c: Glycosylated Hemoglobin Control; DSM: Diabetes Self-Management; SE: Self-Efficacy; SS: Social Support; DK: Diabetes Knowledge. * Correlation is significant at the level $p < 0.05$. ** Correlation is significant at the $p < 0.01$.

Table 3. Multiple Liner regression analysis for various potential predictors of HbA1c.

	Unstandardized Coefficients		Standardized		Collinearity Statistics	
Variables	B	SE	Beta	*p*	Tolerance	VIF
(Constant)	12.227	0.798		0.000		
Marital status	− 1.541	0.447	− 0.307	0.001	0.503	1.988
Level of education	− 0.736	0.350	− 0.147	0.037	0.818	1.223
DSM	− 0.360	0.125	− 0.198	0.004	0.848	1.179
SS	− 0.801	0.314	− 0.172	0.012	0.880	1.136

DSM: Diabetes Self-Management, SS: Social Support.

HbA1c mean value for the younger participants was more than the older participants [34]. It is likely that the longer duration of living with diabetes has contributed to better glycemic control. In the current study sample, 78.9% of participants in the age group (29–39 years) were diagnosed with diabetes for 5.1 years compared to 61% for younger participants (18–28 years). Longer duration living with diabetes is associated with better exposure to diabetes education and a better understanding of diabetic self-management strategies [18].

Furthermore, this study showed a significant relationship between HbA1c and marital status. The mean value for the participants who were married ($M = 7.7$, $SD = 2.0$) was less than those who were single ($M = 9.3$, $SD = 2.7$, $p = 0.000$). This could be explained by the spouse having helped them with daily management of diabetes such as reminding them about medication and monitoring blood glucose and going with them for walking [19]. Another finding from the current study showed a significant association between HbA1c and having children. The HbA1c mean values for the participants who had children ($M = 7.8$, $SD = 2.2$) were lower than those who did not have children ($M = 9.0$, $SD = 2.6$, $p = 0.000$). Diabetes persons may perceive more threats from the consequences of diabetes and losing their role in life and toward their family because of associated complications which will motivate them to adhere to DSM behavior [19].

Further, the HbA1c mean value for the participants with a diploma degree or above ($M = 8.0$, $SD = 2.0$) was lesser than those with a secondary degree or less ($M = 9.1$, $SD = 2.8$, $p = 0.003$). The level of education was associated with a better understanding of diabetes and DSM behavior, which will be visible in the glycemic control value. Furthermore, the current study revealed that the mean value for the employed participants ($M = 7.7$, $SD = 2.0$) was lesser than those who were unemployed ($M = 9.1$, $SD = 2.6$, $p = 0.000$). The adherence to the DSM behavior could explain this result since the glycemic control is the end result of the glycemic control. In AlRahbi's study [18] reported that employed diabetes was performing DSM behavior regularly more than unemployed diabetes. The researcher explained that the employed participants had a higher level of education that mediated the practice of DSM behavior [18]. In the current study, employed participants had higher education (66%) than unemployed participants (39%) which explains this variation.

In the current study, the mean value for the participants who did not have admission in the last year ($M = 8.3$, $SD = 2.3$) was lesser than those who had admission in the last year ($M = 9.2$, $SD = 2.9$, $p = 0.03$). This reflects the fact that patients who had better glycemic control had a lesser chance of being hospitalized. This result was supported by previous research that demonstrated that the admission rate can be reduced by improving DSM and ultimately improving glycemic control [37]. This conclusion is consistent with the other results from our study which demonstrated that diabetes people with better DSM and DK had better glycemic control (i.e. less HbA1c). These results emphasize the importance of interventions that can improve glycemic control by improving the DSM and improving the DK.

Finally, in the current study, the HbA1c mean value for the participants who had an HCP family member ($M = 8.1$, $SD = 2.5$) was better than those who did not have an HCP family member ($M = 8.9$, $SD = 2.5$, $p = 0.03$). In the study by Alhadhrami et al. [27], reported the significant relationship between the presence of members of the HCP family and DSM, which mediated the effect of glycemic control (HbA1c) [27]. Family members from a healthcare background are more knowledgeable and skillful in relation to diabetic care. This makes them available to provide support to their diabetic relative. Which can enhance their DSM and untimely glycemic control.

The regression analysis in the current study revealed that marital status, level of education, level of DSM and social supports are significant predictor of the glycemic control among adult Omanis with T1DM. These factors seem to play an important role in the process of glycemic control among people with DM. Similar results were observed in other international studies such as in Saudi Arabia [38], Romania [35], and Hungary [36]. The results from our study demonstrated that SS is a significant predictor of the glycemic control. This finding was observed by other studies [39,40]. The relationship between glycemic control and SS seems to be mediated by DSM [40]. This conclusion is supported by results from previous research [27], in which the DSM was positively associated with SS. Likewise, the higher level of education was a significant predictor of the glycemic control. The relationship between glycemic control and educational level seems to mediating by the diabetic knowledge level. It is expected that person with higher level of education is more aware of the self-management skills and knowledge. This conclusion is supported by results from previous research [27], in which the DSM was positively associated with the diabetic knowledge findings was observed by other studies. Finally, the considerably low overall R^2 (0.22, adjusted R^2: 0.18) is expected. The glycemic control is a complex phenomenon and many factors are expected to contribute to it.

5. Limitations

Although this study can be considered one of earliest studies to explore the glycemic control among Omanis with T1DM, a few limitations are worth to mention. First, the current study utilized the correctional approach to collect the data. The dynamic of the glycemic control among diabetic people is highly likely to be affected time dimension. Therefore, it would be better to explore glycemic control using the longitudinal approach which will overcome possible seasonal effect. Furthermore, the current study is an observational study. Therefore, the data do not imply any causation inference. Finally, the study was unable to link the glycemic control empirically with patients' outcomes such as diabetic complications. Therefore, future research should consider assessing the association of the glycemic control with the short-term and long-term complications within this population.

6. Conclusions

The results of the current study revealed different clinical implications. Glycemic control is the optimal goal of the therapeutic management of T1DM. Results from our study suggest that clinicians can contribute to achieving this goal by working with diabetic patients to enhance their DSM. Our results suggested that better glycemic control could be achieved by optimizing DSM, social support, and DK. With evidence from the current study and previous research, healthcare policymakers and clinicians are to invest more in developing and implementing customized interventions that can improve diabetic knowledge and diabetic self-management skills. Sociodemographic factors like age, level of education, marital status, and employment status should be considered when developing such interventions or treating individuals with T1DM to reach good glycemic control. Finally, although the results of this study supported the conclusion that enhanced glycemic control is associated with improved patient outcomes, it is important to note that the data were collected over 12 months only. Examining the patients' outcomes using a longitudinal approach over an extended period could strengthen the conclusion. In addition to this, incorporating a qualitative approach to future research can give insight into the personal dimension of diabetic self-management within this population.

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Declaration of interest

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Ethics statement

This study was conducted in accordance with the recommendations of the Helsinki Declaration and all participants signed an informed consent.

Data availability statement

The datasets generated and/or analyzed during the current study are not publicly available due [to restrictions by the Research and Ethics Committee in the College of Nursing at Sultan Qaboos University to protect the participants' privacy] but are available from the Principal Investigator (RAH) on reasonable request.

Author contribution statement

Rajaa Al-Hadhrami is the principal investigator and was responsible for data collection and drafting of the first version of the manuscript. Omar Al-Rawajfah conducted the analysis and contributed to the discussion and review of the manuscript. Joshua K. Muliira and Atika Khalaf assisted in the interpretation of the findings, contributed to the writing, and reviewed and revised the manuscript critically. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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